DOCUMENT RESUME

ED 022 034 VT 005 467

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CIVIL ENGINEERING TECHNOLOGY CONSULTANTS' WORKSHOP (ATLANTA, GEORGIA, MAY 17-20, 1967).

American Association of Junior Colleges, Washington, D.C.

Pub Date 68

Note- 32p.

Available from- American Association of Junior Colleges, 1315 Sixteenth St., N. W., Washington, D. C. 20036 ($1.50)

EDRS Price MF-$0.25 HC-$1.36

Descriptors- *CIVIL ENGINEERING, CONSULTANTS, CURRICULUM, EDUCATIONAL FACILITIES, *ENGINEERING TECHNICIANS, INSTRUCTIONAL STAFF, *JUNIOR COLLEGES, MANPOWER NEEDS, OCCUPATIONAL INFORMATION, PROGRAM DEVELOPMENT, *PROGRAM PLANNING, *TECHNICAL EDUCATION, WORKSHOPS

Identifiers- Occupational Education Project

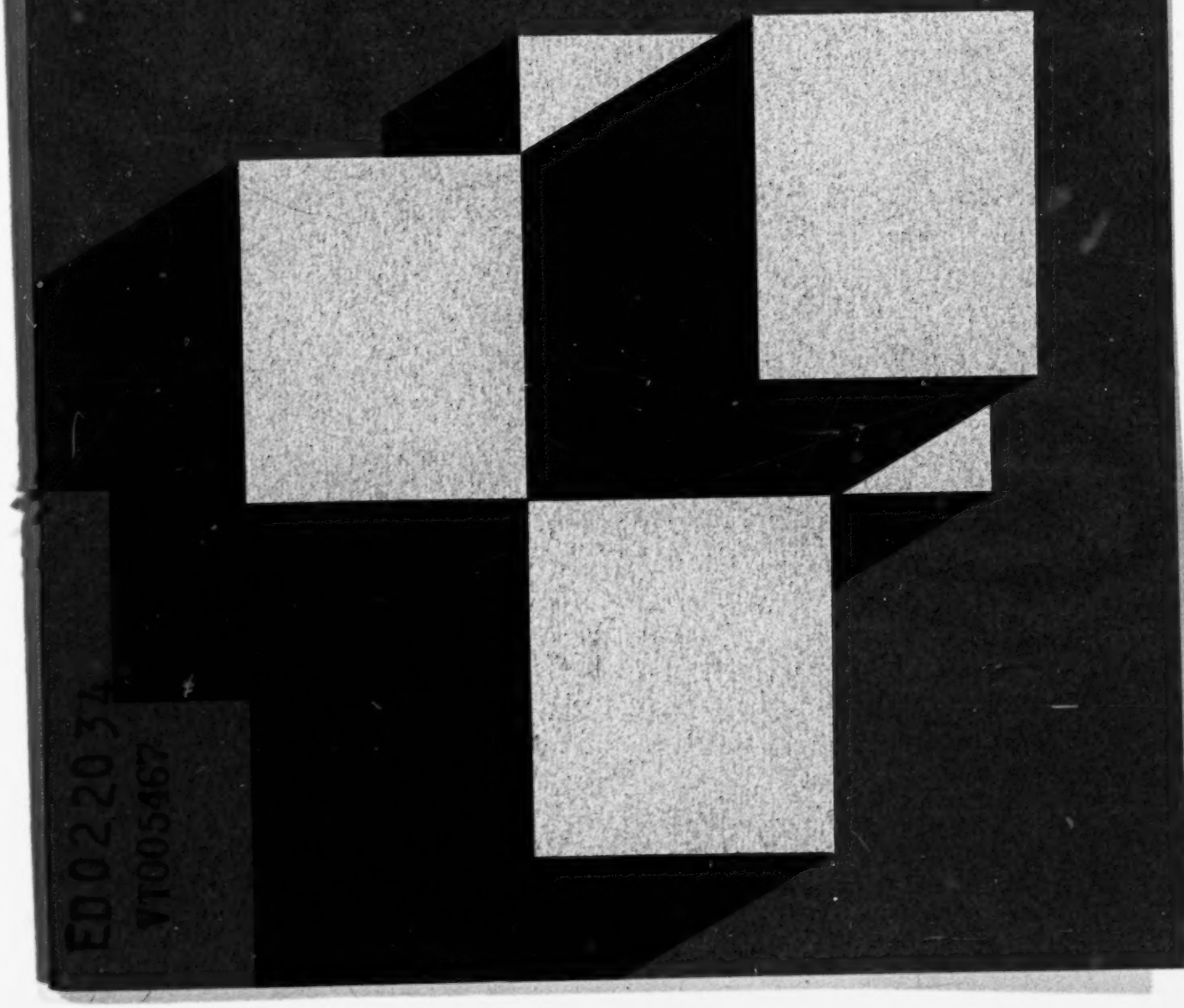
A consultants' workshop was conducted by the Occupational Education Project of the American Association of Junior Colleges to orient the consultants to recent developments in civil engineering technology and their responsibilities in program development. This document, a summary of workshop presentations and discussions, is intended as a guide to consultants and as an introduction to civil engineering technology for junior colleges administrators. A consultant should be used by junior colleges in conducting meaningful manpower-need studies to determine the feasibility of instituting a program in civil engineering technology. If the decision is made to establish a program, a consultant should assist in selecting a competent individual to serve as head of the department. This individual would then be responsible for developing the curriculum, staff, and facilities through the involvement of consultants and a local advisory committee. The 2-year program in civil engineering technology should include an integrated sequence of educational experiences with a distribution of approximately 19 credit hours in basic science courses, 15 credit hours in non-technical courses, and 38 credit hours in technical courses. The objectives of the program will determine the requirements for faculty, laboratories, potential student population, and other program facets. (HC)

MAR 28 1968

# REPORT

# CIVIL ENGINEERING TECHNOLOGY CONSULTANTS' WORKSHOP

CONDUCTED BY AMERICAN ASSOCIATION OF JUNIOR COLLEGES
OCCUPATIONAL EDUCATION PROJECT ▪ MAY 17-20, 1967 ▪ ATLANTA, GEORGIA



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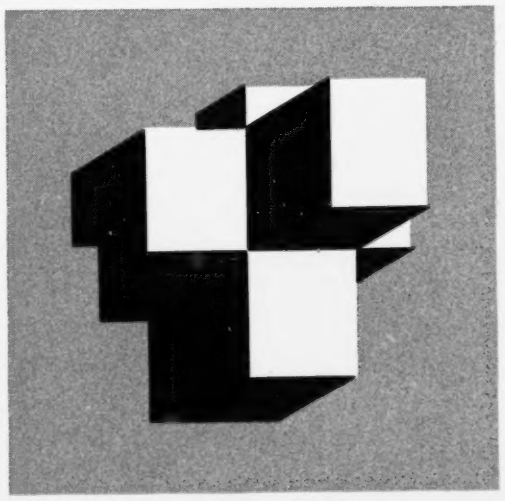
# CIVIL ENGINEERING TECHNOLOGY



# CONSULTANTS' WORKSHOP

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CONDUCTED BY AMERICAN ASSOCIATION OF JUNIOR COLLEGES
OCCUPATIONAL EDUCATION PROJECT • MAY 17-20, 1967 • ATLANTA, GEORGIA

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Printed in U.S.A.

# PREFACE

The Occupational Education Project (OEP) of the American Association of Junior Colleges has as a major objective the development in American junior colleges of occupational education programs. These would serve the manpower needs of local regions and of the nation as a whole, and be congruent with the needs, abilities, and aspirations of students in the junior colleges. One facet in the accomplishment of this objective is making available to junior colleges and to other institutions a corps of qualified consultants to assist in program development.

To identify such consultants in the field of civil engineering technology and to orient them to recent developments and to their responsibilities, a consultants' workshop was held in Atlanta, Georgia, in May 1967. Approximately forty leaders in this field met for two and a half days and held extensive discussions.

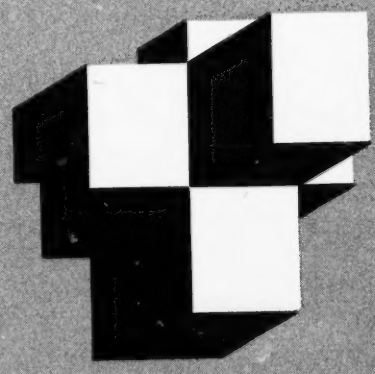
Jerry S. Dobrovolny, professor and head, Department of General Engineering, University of Illinois, Urbana, participated in the meeting as a discussion leader and has undertaken in this publication to summarize the discussions. In this, he has leaned heavily on the presentations made at the workshop by: Kenneth G. Skaggs, coordinator, Occupational Education Project, AAJC, on "The Consultant and the College"; Charles T. Holladay, head, Civil Engineering Technology Department, Southern Technical Institute, Marietta, Georgia, on "The Civil Engineering Technology Curriculum"; Richard L. Rinehart, president, Bay de Noc Community College, Escanaba, Michigan, on "Need for Civil Engineering Technicians"; and Stephen G. Steele, chairman, Civil Technology Department, Broome Technical Community College, Binghamton, New York, on "Implementing the Curriculum: Facilities and Staffing."

This publication is intended both as a guide to consultants who will be engaged in these activities, and as an introduction to civil engineering technology for junior college administrators formulating programs in this field. The OEP office will gladly furnish to interested parties the names of qualified consultants.

The activities of the OEP are supported by a grant to the Association from the W. K. Kellogg Foundation of Battle Creek, Michigan.

Lewis R. Fibel
Specialist in Occupational
Education, AAJC

# INTRODUCTION

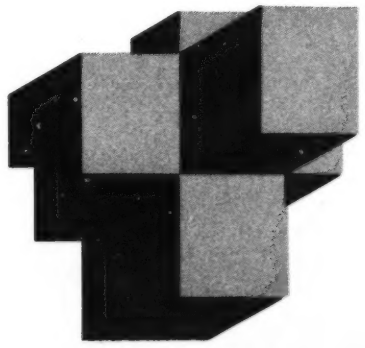


The concept of post-high school technical education in the United States is not new; however, only in recent years has significant progress been made toward a fuller realization of the need for program implementation. The National Defense Education Act of 1958 and the Vocational Education Act of 1963 have given impetus by providing funds for the training of technicians. The American Society for Engineering Education, under a grant from the National Science Foundation, conducted a study resulting in a report, *Characteristics of Excellence in Engineering Technology Education,*[1] published in 1962. The Technical Education Branch of the U.S. Office of Education has published a wide variety of post-high school curriculum guides for various technologies.

Many problems must be solved before a sound philosophy of technical education is accepted by our society. The need for qualified instructors, knowledgeable school administrators, parental understanding, and student selection techniques are but a few.

The American Association of Junior Colleges, through the Occupational Education Project, intends to stimulate the development of occupational education programs in the junior colleges. An early effort under this project brought into focus the need for programs in civil engineering technology. To assist in this effort, a workshop for consultants knowledgeable in the field was held in Atlanta, Georgia, May 17-20, 1967. The logical development of a civil engineering technology program at a two-year community college was determined to consist of several steps which include: determining the need for civil engineering technicians, the use of a consultant, the structuring of the curriculum, determining the required physical facilities, and identifying the competency requirements of the staff. A formal presentation of each of the main topics was followed by group discussion. This report deals with the highlights of the workshop with the intent to provide information that can be used by community college administrators and staff.

# CIVIL ENGINEERING TECHNOLOGY CONSULTANTS' WORKSHOP



To understand the role of the civil engineering technician on the engineering team, a discussion of the various levels of civil engineering work is in order. In any engineering activity, the spectrum of job responsibilities and job titles ranges from the researcher to the common laborer. Each position has a specific function with a related educational preparatory program. A typical job classification system with the related minimum job entry training is shown in Table I.

**Table I**
**Comparison of Job Title with Educational Requirements**

| Job title | Job function | Educational and training requirement | Level of education |
|---|---|---|---|
| Civil engineer | Research and teaching | Ph.D degree | Professional |
| | Design, development, construction, and management | B.S. and M.S. degrees | |
| Civil engineering technician | Assist in design, development, construction, and supervision | Associate degree | Technical |
| Civil engineering aide | Drafting, field and laboratory assistance (surveying, materials testing, etc.) | Certificate program ranging from several weeks to a year | |
| Craftsman | Manufacture and construction (carpenter, machinist, bricklayer, etc.) | Trade-apprenticeship programs | Vocational |
| Machine operator | Operates specific machine (bulldozer operator, machine operator, etc.) | Specialized training programs up to one year in length | |
| Common laborer | Manual labor | Literate and able bodied | |

The three principal job titles and their related job entry requirements in this report are the civil engineer, the civil engineering technician, and the civil engineering aide. Engineering has been defined "as the art and science of applying the laws of the natural sciences to the transformation of materials for the benefit of mankind." Applying this definition to civil engineering, we find that it includes the design and construction of highways, bridges, buildings, waterways, dams, pipelines, sanitary systems, foundations, airplanes, missiles, railroads, airports, hydroelectric plants, irrigation systems, and a host of other systems and structures of our civilization. The civil engineer, civil engineering technician, and the civil engineering aide work at various levels of the total engineering complex.

**The Civil Engineer**

The civil engineer is a professional man who is responsible for the design and construction of civil engineering works. He must have a thorough grounding in fundamental mathematics, physical sciences, engineering sciences, engineering analysis, and engineering design. To prepare for this responsibility, he must have at least a bachelor of science degree in civil engineering. More and more, those involved in critical design activities require a master's degree in civil engineering. In addition to this formal education, he must meet certain state registration requirements as a registered professional engineer, a registered structural engineer, or a registered land surveyor. In 1955 the following definition was adopted by the Conference of Engineering Societies of Western Europe and the United States:

**A professional engineer** *is competent by virtue of his fundamental education and training to apply the scientific method and outlook to the analysis and solution of engineering problems. He is able to assume personal responsibility for the development and application of engineering science and knowledge, notably in research, designing, superintending, construction, manufacturing, managing, and in the education of the engineer. His work is predominantly intellectual and varied, and not of a routine mental or physical character. It requires the exercise of original thought and judgment and the ability to supervise the technical and administrative work of others.*

**Civil Engineering Technician**

In *Characteristics of Excellence in Engineering Technology Education* (1962), engineering technology is defined as follows:

**Engineering technology** *is that part of the engineering field which requires the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational area between the craftsman and engineer at the end of the area closest to the engineer.*

The educational program for a civil engineering technician is normally two years at the post-high school level and is identified as an associate degree program in technical education. The U.S. Office of Education's Cooperative Project for Standardization of Terminology in Instructional Programs of Local and State School Systems has in its third draft of *Standard Terminology for Instruction in Local and State School Systems* [2] published the following definition of technical education:

**Technical education** *is concerned with that body of knowledge organized in a planned sequence of classroom and laboratory experience usually at the postsecondary level to prepare pupils for a cluster of job opportunities in a specialized field of technology. The program of instruction normally includes the study of the underlying sciences and supporting mathematics inherent in a technology; and of the methods, skills, materials, and processes commonly used and services performed in the technology.*

The civil engineering technician can be found in a wide range of job classifications. He will work very closely with the civil engineer doing detailed design work, testing materials, surveying, estimating, supervising construction, report writing, and a host of other engineering functions. Many functions previously performed by the civil engineer are today performed by the civil engineering technician. The technician generally will not hold prime responsibility for design or construction of engineering projects since this is the responsibility of the registered professional engineer, architect, or land surveyor. As a technician matures on the job, he will probably assume a greater responsibility for some parts of the system or project, but in all cases he will remain accountable to the professional engineer. He may act as chief of party for a surveying crew or head up the materials testing laboratory as well as holding other responsible positions.

Proper use of the civil engineering technician provides the practicing engineer with more time for creative work. In job situations where the technician has been utilized to his fullest potential, the engineering talent has been able to undertake a higher level of engineering work with a wider range of intellectual involvement.

## Civil Engineering Aide

The engineering manpower team concept has recently been expanded to include an intermediate level that can most appropriately be identified as an engineering aide. The civil engineering aide works in the occupational spectrum between the craftsman and the engineer in the area closer to the craftsman.

The preparatory program for a civil engineering aide may be up to one year at the post-high school level and is identified as a certificate program. The one-year certificate program emphasizes the applied laboratory aspects of civil engineering. The mathematical requirements are applicatory and related specifically to surveying, laboratory calculations, and drafting.

The civil engineering aide may be employed as a draftsman, a surveying crew member, a materials laboratory tester performing various routine tests, or as an assistant to the civil engineer or the civil engineering technician. He also works on construction assisting in supervision under the direction of a civil engineer.

## The Certification of Engineering Technicians

The National Society of Professional Engineers has established the Institute for the Certification of Engineering Technicians. The purpose of the institute is to identify those engineering technicians who, through education and work experience, have reached a level of competency in engineering to be identified as certified engineering technicians. As evidence of satisfactory attainment, the institute grants certificates in any of the three grades authorized and also maintains a registry of certificate holders. The three grades of engineering technicians recognized by the institute have the following requirements:

**Junior Engineering Technician:** *The applicant must have either two years of experience in work requiring elementary technical ability as evidenced by the endorsement of a professional engineer or equivalent or be a graduate of an Engineers' Council for Professional Development accredited program in some field of engineering technology.*

**Engineering Technician:** *The applicant must meet one of the requirements for the grade of junior engineering technician and must have five additional years of applicable experience as evidenced by the endorsement of two professional engineers or equivalent. He must be at least twenty-five years of age and may be required to pass an examination.*

**Senior Engineering Technician:** *The applicant must meet the requirements for the grade of engineering technician and must have at least ten additional years of experience of a high-level detailed technical nature as evidenced by the endorsement of three professional engineers or equivalent. He must be at least thirty-five years of age.*

*It is not expected that these three grades will alter the classification schemes within company or governmental establishments, but the possession of a nationally recognized certificate should be immediately meaningful inasmuch as it does indicate the attainment of certain minimum experience and educational background. The fact that the seeking of certification on the part of an engineering technician is purely voluntary should be most significant to employers and to engineers with whom the engineering technician works in the team relationship.*

### Job Opportunities for Civil Engineering Technicians

In a recent study of the Engineering Manpower Commission,[3] salaries of technicians were found to average from $4,908 a year for the beginning technician to $9,547 for the average technician with sixteen years experience. Graduates of two-year associate degree programs in civil engineering technology have a median starting salary of $6,000 upon graduation, with a range from $5,000 to $7,500 a year depending upon previous work experience. As a rule, the graduate technician has had some significant work experience prior to graduation. More likely than not he has worked for a while before returning to school to obtain his associate degree. In many cases he will have participated in a work-study program whereby he went to school for a semester or a quarter and worked for the highway department or a civil engineering firm during the summers or in alternate quarters or semesters. This accounts for the upper range of $7,500 a year.

This Engineering Manpower Commission's study clearly indicates that graduates of two-year civil engineering technology programs progress more rapidly and reach higher salary levels than do technicians who do not have an associate degree. The report indicates that some civil engineering technicians earn up to $20,000 a year.

More and more civil engineering concerns are recognizing the need for a job classification to properly identify civil engineering technicians by the work they are doing. In many state highway departments, job classifications have been established for engineering technicians at various levels of responsibility.

**Table II**
**Monthly Salary Ranges for Various Grades**
**Of Technical and Engineering Staff***

| Civil engineer (CE) | | Civil engineering technician (CET) | | Civil engineering aide (CEA) |
|---|---|---|---|---|
| Chief Highway Engineer | $2000-2500 | | | |
| CE VIII | $1550-2000 | | | |
| CE VII | $1400-1850 | | | |
| CE VI | $1250-1600 | | | |
| CE V | $1150-1425 | | | |
| CE IV | $ 900-1275 | | | |
| CE III | $ 850-1150 | CET IV | $850-1150 | |
| CE II | $ 750-1000 | CET III | $700- 970 | |
| CE I | $ 650- 900 | CET II | $500- 800 | |
| | | CET I | $350- 650 | |
| | | | | CEA I $275-500 |

**Excerpted from the Salary Adjustment Plan for Technical and Engineering Staff of the Illinois Division of Highways.*

As the demand for trained professional and technical personnel increases, the adoption of this type of salary schedule is a must if we are to properly reward and identify the work of the civil engineer, the civil engineering technician, and the civil engineering aide.

**Manpower-Need Studies**

When organizing a curriculum in civil engineering technology in a new school or in an established institution, a thorough manpower-need study of the locale must be made. A look at some of the national studies concerned with the shortage of engineering technicians provides a base for the local study.

In 1956, the President of the United States appointed a Committee on Scientists and Engineers to investigate the shortage of scientific manpower.

This committee devoted considerable time to discussion of the importance of technicians on the engineering manpower team. The final report to the President, dated December 1958, states:

*The members of the President's committee are unanimous in the belief that the manpower problems of technicians are at least as severe as the problems of scientists and engineers.*

At the same time that this committee was active, G. Ross Henninger undertook the study of technical institute education in the United States under a Carnegie grant and the sponsorship of the American Society for Engineering Education. The report came out in its final form in 1959.[4] This was the first meaningful identification of schools offering post-high school programs in engineering-related technologies.

Much has been written since the Henninger report concerning the desirable ratio of engineering technicians to engineers. The generally accepted figure of three technicians per practicing professional engineer has been accepted as an optimum. There are many problems in the implementation of the three-to-one goal; among them is the problem of acceptance of the technician by the practicing engineer. However, this situation is disappearing as the engineering technicians are performing their roles successfully upon entering their jobs.

The *Engineering News Record* of July 20, 1967, had an editorial that stated in part the following:

*Serious and sensible thought is being given these days to the education, the role, and the recognition of the engineering technician. And well there might be. For, while the graduate of the two-year technical institute is not a new phenomenon, our education system is going to be turning him out in greatly increasing numbers.*

*The use of the civil engineering technician in the construction industry is not nearly so common as is the use of engineering technicians in manufacturing industries, where they are better and longer established. But this much is sure: Civil engineering technology curricula will be springing up in impressive numbers.*[5]

To determine the need for civil engineering technicians in a community, the future employers of the graduates of two-year associate degree programs must understand just how the technician can be used in their particular organizations. Very little information is available to determine the needs for engineering technicians in a particular locality for a particular

type of technology. Therefore, various indices related to the overall manpower demands for engineers and scientists must be used.

The Engineering Manpower Commission, in a recent publication entitled *Demand for Engineers and Technicians—1966,* indicates that 94 per cent of the state government engineers have civil engineering degrees.[6] The projected trends indicate that this will continue. This report also indicates that the percentage of civil engineers who are employed in federal government operations will increase from 29 per cent to 40 per cent, whereas the civil engineers in consulting will decrease from 61 to 46 per cent, and in local governments from 87 to 73 per cent. Therefore, if the ratio of three technicians per engineer is applied, the demand for civil engineering technicians will increase at a greater rate than for civil engineers.

Table III indicates that the per cent increase for technicians from 1965 to 1976 will be significantly greater than for engineers. Table III is taken from the above-mentioned publication.

**Table III**
**Future Needs for Civil Engineers and Civil Engineering Technicians**

| | Per cent of civil engineers hired for this activity | | Per cent increase in technicians from samples |
|---|---|---|---|
| Activity | 1966 | 1976 est. | 1965-1976 |
| Aerospace | 9% | 8% | 62% |
| Construction | 40 | 39 | 58 |
| Consulting | 61 | 46 | 61 |
| Research | 1 | 1 | 27 |
| Transportation | 7 | 27 | 133 |
| Utilities | 10 | 7 | 12 |
| Federal government | 29 | 40 | 13 |
| State government | 94 | 92 | 22 |
| Local government | 87 | 73 | 27 |
| Education | 15 | 14 | 104 |

In developing data for an area need study, care must be taken to review all available related studies that have been done for the local geographic area. A good source can often be developed from the feasibility study that was undertaken to determine whether the local junior college should be established in the first place. The general economic analysis of the area along with projected increases in construction projects over the next decade are also important indices. Oftentimes, studies that have been completed in other parts of the country will be a guide to what can be expected in the particular local area.

One of the most effective ways of obtaining meaningful data in terms of actual numbers of engineering technicians required in the area is to conduct in-depth interviews with representative employers of technicians in the community. Care must be taken to structure the survey instruments used to provide a narrower range of responses than would normally be obtained in an overall manpower need study. Wherever possible, questions should be used that can be related to other surveys, so as to correlate the results of the studies.

Involving various key people in the community in the study is an important factor in obtaining meaningful information. High school guidance counselors, for example, can be used in establishing the expectations of high school graduates. The guidance counselors must have a thorough understanding of what civil engineering technology consists of. A separate advisory committee can be used effectively in implementing the study.

After the local needs have been determined they must be related to state and national needs. The instruments used in the survey should not be structured on the traditional lines of a job analysis for a manipulative skill occupation. The work of the technician does not always follow a definite cycle, but may vary from day to day, from one project to another. Hence, the work does not always lend itself to the job analysis techniques that have been used by industrial and vocational educators.

Various combinations of plans can be used to obtain the necessary data for a successful local need study. The personal interview technique, coupled with appropriately structured questionnaires, often provides an extremely effective means of obtaining the necessary data. Sending questionnaires through the mail without any personal follow-up oftentimes produces poor results; first, from the standpoint of a poor return of the questionnaires, and secondly, the misunderstanding of the responder in terms of information being sought.

## The Use of a Consultant

The rapid expansion of program implementation at the two-year college level has made it almost impossible to provide sufficient staff for all of the schools that are planning programs in civil engineering technology.[7] In 1966 more than fifty new junior colleges were established. In 1967, the number was more than seventy. An effective way to provide the administrator with sound planning is for him to use a qualified consultant. Several types of consultants are being sought by junior colleges. One type would have a general overview of responsibility in the establishment of the college. Another is a subject matter specialist for a particular program to be implemented.

Colleges often have difficulty locating the kinds of consultants they need. Some sources of consultants are professional organizations, other colleges, state departments of education, personal inquiries, and, for the civil technology programs, the American Association of Junior Colleges.

To begin with, a consultant must play each situation by ear so that he can find out just what the college is asking for; whether he is to be an adviser, an arbitrator, a decorator, a dispenser, an evaluator, or fire fighter. The college has certain responsibilities when it seeks the services of a consultant. It must state specifically the purposes of the assignment, and in the letter of invitation should state the conditions of the visit including the financial basis of the services. Arrangements should be made to provide the consultant with housing, along with a place to work and to confer. He should have an opportunity to meet some of the key personnel in a friendly environment. Appropriate publicity should be arranged with the local news media. Time should be allowed in his schedule so that the consultant can sit down and think while he is collecting some of the data. After the initial contact and arrangements have been made, a letter of confirmation and reaffirmation of arrival schedules, etc. should be written.

One desirable characteristic of the consultant is that he must be objective. He must have a spirit of independence, have integrity, patience, and tact. He must treat all of the information in a confidential manner. He cannot serve two or more institutions at the same time. He must accomplish his work expeditiously and complete the work in a reasonable length of time.

When the consultant is first contacted by the college, he must make certain that the fees are predetermined so that there will be no misunder-

standing upon the completion of the work. He must make certain during the initial negotiations that his role is stated clearly by the college. If there are to be any changes, these must be discussed in advance.

When a consultant is accepting an appointment, he should confirm all arrangements by letter; he should study all of the materials relating to the school and the problem before going to the college; he should attempt to understand the personalities that would be involved in his visit; he should prepare preliminary drafts of the report, perhaps while he is on the consulting site; he should not divert from the central purpose of the visit while on the job; he should not be too positive while he is meeting with the people at the college; and he should not accept all statements at face value.

The consultant must adhere to professional standards which include his abilities to be thorough and accurate, to study the problem completely, to make specific recommendations, to write a short report, not to take sides, and to use time wisely. A follow-up visit is often necessary. Normal consultant's fee ranges from $100 to $150 a day. In addition, the consultant should receive reimbursement for travel and subsistence.

The consultant should be familiar with the following: manpower need studies at the local, state, and national levels; the Engineering Council for Professional Development accreditation criteria for programs of engineering technology, regional accreditation requirements; the report, *Characteristics of Excellence in Engineering Technology Education;* federal and state legislation pertaining to vocational and technical education; and the impact of the goals study of engineering education on future program development in engineering technology. He should be aware of sources of curriculum material including the two-year post-high school curriculum guide on civil technology with the highway and structural options published by the U.S. Office of Education.

## The Civil Engineering Technology Curriculum

When a junior college embarks on a program to prepare civil engineering technicians, care must be taken to delineate the differences in job functions of an engineering aide, an engineering technician, and a civil engineer. After this delineation is clearly established, the type of education program required to prepare these various levels of personnel must be discussed. Specifically, the two-year associate degree program in civil engineering technology has unique characteristics that set it apart from

other preparatory programs. Some junior colleges may already have pre-engineering programs and care must be taken not to confuse the objectives of the two-year program of civil engineering technicians with the two-year pre-engineering program to prepare civil engineers.

The two-year program in civil engineering technology is a college-level program, but it differs significantly from a pre-engineering curriculum. The first two years of an engineering curriculum are devoted primarily to mathematics, science, and general education with very few specialized technical courses. On the other hand, the engineering technology curriculum must initiate specialized technical courses early in the program if the desired objectives are to be accomplished within the time available. The sequencing of courses and topics must be carefully organized to permit the students to develop to the desired levels of competence. An engineering technology curriculum must be rigorous and taught at the college level. It must be structured so that it prepares the graduate functionally to enter a job and be immediately productive with a minimum of on-the-job training. It must provide the technical and scientific background to prepare him to keep abreast of the developments of technology throughout his career. It should enable the graduate with a reasonable amount of industrial experience to advance into positions of increased responsibility.

In addition, it must also include sufficient work in nontechnical areas to prepare the individual to participate fully in the society. In recent years, a number of studies have been completed to help identify the guidelines that can be used to properly organize and structure a program of engineering technology. In 1962, the American Society for Engineering Education published *Characteristics of Excellence in Engineering Technology Education.* In March 1962, the U.S. Office of Education published a bulletin entitled *Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs.*[8] Both publications have provided a sound basis for curriculum construction in programs of engineering technology. Significantly, the analogy is that they agree very closely in

terms of the amount of time to be spent in various subject areas. The distribution of credit hour time for the major course groups is approximately as follows:

**Table IV**
**Curriculum Summary in Credit Hours**

| | | |
|---|---|---|
| **BASIC SCIENCE COURSES** | | |
| Mathematics | 10 hrs. | |
| Physical sciences | 9 hrs. | |
| | | 19 hrs. |
| **NONTECHNICAL COURSES** | | |
| Communications | 6 hrs. | |
| Humanistic-social studies | 9 hrs. | |
| | | 15 hrs. |
| **TECHNICAL COURSES** | | |
| Technical skills | 6 hrs. | |
| Technical specialties | 32 hrs. | |
| | | 38 hrs. |
| | Total | 72 hrs. |

In addition to the above-mentioned guides for organizing a curriculum, the U. S. Office of Education has published in their technical education program series a suggested post-high school curriculum for *Civil Technology: Highway and Structural Options*.[9] The curriculum guide follows closely the suggested breakdown of subject area coverage in the two previously mentioned documents. This curriculum guide can be used as a point of departure for developing programs for any particular locality. The suggested curriculum with the highway option and structural option appearing in this publication are shown in Table V.

**Table V**
**Civil Engineering Technology Curriculum**

*Highway and Structural Options*

*Hours per week for 16-week semester*

| COURSE TITLE | Class | Lab. | Outside Study | Total | Cr.Hrs. |
|---|---|---|---|---|---|
| FIRST SEMESTER | | | | | |
| Materials (chemistry and properties) | 2 | 3 | 4 | 9 | 3 |
| Technical drawing | 1 | 7 | 4 | 12 | 4 |
| Technical mathematics I | 5 | 0 | 10 | 15 | 5 |
| Technical physics I (mechanics) | 3 | 2 | 4 | 9 | 3 |
| Communication skills | 3 | 0 | 6 | 9 | 3 |
| Highway and structural technology seminar | 1 | 0 | 2 | 3 | 0 |
| | 15 | 12 | 30 | 57 | 18 |
| SECOND SEMESTER | | | | | |
| Construction methods and equipment | 3 | 0 | 6 | 9 | 3 |
| Mechanics (statics and dynamics) | 3 | 0 | 6 | 9 | 3 |
| Surveying and measurements | 2 | 6 | 4 | 12 | 4 |
| Technical mathematics II | 5 | 0 | 10 | 15 | 5 |
| Technical physics II | 3 | 2 | 4 | 9 | 3 |
| | 16 | 8 | 30 | 54 | 18 |

## Highway Option

*Hours per week for 16-week semester*

| COURSE TITLE | Class | Lab. | Outside Study | Total | Cr.Hrs. |
|---|---|---|---|---|---|
| **THIRD SEMESTER** | | | | | |
| Advanced drafting (highway) | 1 | 7 | 4 | 12 | 4 |
| Industrial organizations and institutions* | 3 | 0 | 6 | 9 | 3 |
| Soils and foundations | 2 | 3 | 4 | 9 | 3 |
| Streagth of materials | 3 | 2 | 6 | 11 | 4 |
| Technical reporting | 2 | 0 | 4 | 6 | 2 |
| Photogrammetry | 1 | 3 | 2 | 6 | 2 |
| | 12 | 15 | 26 | 53 | 18 |
| **FOURTH SEMESTER** | | | | | |
| Drainage and geology | 3 | 3 | 6 | 12 | 4 |
| Reinforced concrete construction | 3 | 2 | 6 | 11 | 4 |
| Roadway design and construction | 3 | 4 | 8 | 15 | 5 |
| Route design and surveys | 2 | 4 | 4 | 10 | 3 |
| Legal and economic aspects of engineering | 2 | 0 | 4 | 6 | 2 |
| | 13 | 13 | 28 | 54 | 18 |

## Structural Option

| COURSE TITLE | Hours per week for 16-week semester: Class | Lab. | Outside Study | Total | Cr.Hrs. |
|---|---|---|---|---|---|
| **THIRD SEMESTER** | | | | | |
| Advanced drafting (structural) | 2 | 8 | 5 | 15 | 5 |
| Industrial organizations and institutions* | 3 | 0 | 6 | 9 | 3 |
| Soils and foundations | 2 | 3 | 4 | 9 | 3 |
| Strength of materials | 3 | 2 | 6 | 11 | 4 |
| Technical reporting | 2 | 0 | 4 | 6 | 2 |
| | 12 | 13 | 25 | 50 | 17 |
| **FOURTH SEMESTER** | | | | | |
| Applied building construction | 3 | 3 | 6 | 12 | 4 |
| Estimating and office practices | 3 | 4 | 5 | 12 | 4 |
| Reinforced concrete construction | 3 | 2 | 6 | 11 | 4 |
| Structural detailing and design | 3 | 3 | 6 | 12 | 4 |
| Legal and economic aspects of engineering | 2 | 0 | 4 | 6 | 2 |
| | 14 | 12 | 27 | 53 | 18 |

**General and industrial economics (3-hour class) may be chosen as an elective instead of industrial organizations and institutions.*

Invariably the question of transferability of credits to a university program comes up during a discussion of a two-year associate degree program in civil engineering technology. This is relative to the kind of a baccalaureate program to which one will wish to transfer the credits. In the case of the four-year engineering technology program, probably all of the credits would be transferable. On the other hand, if a graduate of a civil engineering technology program decides to pursue a degree in civil engineering, probably about one-half of his credits would be applicable. Probably such courses as engineering graphics, surveying, communications, as well as some of the mathematics and physical sciences would transfer. Only students in the upper quarter of their graduating class should be considered as potential candidates for continuing on in a four-year baccalaureate program of any kind, and probably only the upper ten per cent might be considered as possible candidates for civil engineering programs. Many of the courses in the social sciences and humanities certainly could be transferred to a baccalaureate program.

Probably most of the engineering science courses would not be transferable except in special situations. By and large, the course work offered in the technical specialties and the engineering sciences in the civil engineering technology curriculum would be more application oriented than would be the similar coverage in the baccalaureate engineering program. The consultant should be prepared to answer the question on transferability of credits.

Another very important facet of curriculum construction is the identification of the potential student population that will enroll in the program. It has generally been accepted that a curriculum in engineering technology should be designed for the middle 50 per cent and probably for the second quartile of the high school graduating class, the 50 to 75 percentile having the most likelihood of completing the program. In addition, specific subject matter course requirements must be met for admission to a program of civil engineering technology. These would normally include graduation from an accredited high school with two units of algebra; one unit of geometry or one-half unit each of geometry and trigonometry; one unit of science, either chemistry or physics, preferably both; and the general requirements of English, history, government, etc. It would be desirable to have additional coverage in some of the advanced mathematics areas introducing calculus; however, this is not possible in most parts of the country today.

In addition to requiring an appropriate academic background, some kind of validated testing program with realistic cut-off scores can be used to help select the students. One school (A) is using the Scholastic Aptitude Test (SAT). It uses a cut-off point of 800-plus out of a possible 1600 which combines both verbal and mathematical scores. Another school (B) uses 350 on the SAT as a base cut-off point. School B found that 67 per cent of the people in the 350 to 399 range made a 1.6 average at the end of the first year which enabled them to stay in school. For those students who tested 400 to 499, 75 per cent stayed in school. Of those students in School B who made 1050 to 1099 in their test score, only 15 per cent completed the program. In School A, using the 800 cut-off score, 49.5 per cent graduated. This collection of data seems to indicate that if students were permitted to enter with a lower score, a greater percentage might graduate.

Of those graduating from the civil technology program of School A, 62.5 per cent finished in six quarters, 27.5 per cent finished in seven quarters, and 6.5 per cent finished in eight quarters. The remaining percentage took less than six quarters because they entered with transfer credits and advanced standing.

It becomes evident that another important way of recruiting students is to provide a pretechnical program for those students who do not meet the prerequisites from their high school work.[10] Such pretechnical programs vary from eight weeks to a full semester in length, depending upon local situations. In schools where this has been done, the students who complete the pretechnical program have a high percentage completion rate for the two-year technology program.

In civil engineering technology several options are available for program implementation. The general option would provide work in surveying, structures, water and sewage or sanitation, some hydraulics, etc. Some of the more specialized options are highway, structural, construction, sanitation or waste water, traffic and safety, and a few others. The options selected would be somewhat dictated by local needs.

Upon graduation the graduates of a civil engineering technology program can enter a wide range of job classifications in the civil engineering field. In many cases they will begin as engineering aides doing some drafting and calculations, or they may work in laboratories as testing technicians.

After several years they may work up to group leaders, chief draftsmen, party chiefs, etc. In some cases, with additional academic training, they can become registered professional engineers.

Another important aspect of a program in engineering technology is the work-study or co-op plan. Many times persons who have worked for a while find that their horizons are limited without additional training. However, due to financial obligations, they are not able to go to school on a full-time basis. These students often turn out to be the best students for a program of engineering technology since they have more motivation than the student just out of high school. Experience with graduates of co-op programs has shown that they prove to be excellent employees and rise rapidly in the ranks of the job classifications on the engineering manpower team.

To have a successful co-op program, a staff member must be assigned the responsibility of coordinating the schedules of students going to school and working in engineering offices. While they are working, he must make certain that the experience they are obtaining adds to a well rounded educational program by having them involved in as many facets of the engineering office as is consistent with their training and experience.

It is becoming increasingly important to provide a wider spectrum of program offerings at the junior college to satisfy the capabilities and needs of the total student population. More and more schools are beginning to offer one-year programs to prepare engineering aides. Normally, these programs are occupationally oriented and emphasize manipulative skill. These courses are somewhat different from those for the two-year associate degree candidates. The level of mathematics is considerably lower and is taught in a more applied manner as the need arises for its use in the various subjects being covered. The courses, by and large, are concerned with the "how to," backed up by some theory to give the basic ideas of why something is being done. The content of such a program might include about 10 per cent mathematics, 10 per cent science, 10 per cent communications, with about 45 per cent being devoted to laboratory work in a specialized field of civil technology, and about 25 per cent devoted to classroom theory that backs up the laboratory work. This provides approximately 70 per cent identification with the specialized field and 30 per cent with the related mathematics, science, and communication skills. More time is spent on the use of instruments, practice in the laboratory

conducting the more routine tests, doing some routine calculations and detailed drafting. Some of the types of jobs that such persons are qualified for would be concrete technician in a concrete laboratory, an instrument man on a survey party, an inspector on a particular type of job, a draftsman, a water plant operator, a sewage plant operator, etc. Most of these individuals begin as engineering aides and probably continue as engineering aides unless they change their motivation and do a considerable amount of extra study in additional educational programs.

Upon completion of this one-year program, a certificate is normally awarded. The advantage of offering both the one-year certificate program and the two-year associate degree program is that, as the students enroll in their first term of study, they can be encouraged to work to their maximum potential. Those who start out in the certificate program and are capable of continuing on in the associate degree program, through proper guidance and counseling, can be encouraged to transfer to the higher level program. On the other hand, those who start out in the two-year associate degree program and find that they do not have the motivation or desire or capability to continue, can be encouraged to transfer to the one-year certificate program. In this way a greater number of trained personnel, who otherwise might go undeveloped, can be salvaged and placed on the labor market.

A number of schools are developing four-year baccalaureate programs in engineering technology. Insufficient experience at the present time prevents an adequate analysis of these programs.

**Implementation of a Civil Engineering Technology Curriculum—Facilities and Staffing**

Some of the items described earlier in this report pertain rather specifically to the implementation of a civil engineering technology curriculum. The importance of conducting a meaningful need study of the manpower requirements for civil engineering technicians in a particular area is extremely important in determining the feasibility of instituting a program in civil engineering technology. This need study is necessary for a newly established junior college or community college as well as an existing community college.

The individuals who are contacted in obtaining data for the need study should be involved in the practice of civil engineering in the local area since they are most closely involved with the manpower needs as well as with the supervision and employment of potential graduates of the

program. The results of the need study can help determine what kind of a civil technology program should be offered, whether it should be of a general nature or one of the more specialized options such as highway, structural, surveying, or water and waste water.

After the decision has been made by the college administration to establish a program in civil engineering technology, the most important step in implementation will be to seek the services of a competent individual to serve as head of the department. He should be employed at least one year prior to the beginning of classes in the particular curriculum. If possible, he should have had previous experience in administering or teaching in a program of civil technology. He should have at least a bachelor's degree in civil engineering, preferably a master's degree, along with significant experience in the practice of civil engineering. It is also desirable that he be a registered professional engineer. He must have a thorough understanding of technical education and be sympathetic toward it, and he must have a strong desire to teach and work with young people.

Once he has been employed he should be given the responsibility for developing the department. One of the first activities that he should become involved in is the selection of an appropriate advisory committee for the civil engineering technology curriculum.[11] This committee will form a liaison between the school and the public. Some of the people who were contacted in obtaining the data for the need study are logical candidates for membership. The committee members should represent a large percentage of the potential employers of the graduate engineering technicians.

Concurrent with this involvement of the local advisory committee, the basic curriculum should be developed. One of the first decisions that might have to be made would be whether to structure the curriculum in a two-year four-semester schedule or a two-year six-quarter term system. Experience has shown that the six-quarter term system has many advantages when it comes to organizing associate degree programs in civil engineering technology. In the four-semester programs the courses must cover a variety of topics and sometimes become what may be called "hybrids." The six-quarter term system provides the opportunity to arrange the courses in a meaningful sequential manner and thereby provide the necessary prerequisites for topics in subsequent quarters. Greater flexibility is afforded by the use of the six-quarter system. The sequencing of courses and topics must be carefully organized to permit the student to develop to the desired levels of competence. An engineering technology curriculum must be equivalent in rigor of effort required for a college level program.

After the curriculum has been fairly well established, additional faculty members must be hired, and equipment for the various laboratories must be ordered. Manufacturers' catalogs can be obtained to assist in determining costs and types of equipment to be ordered. Reference is made to the civil curriculum guide published by the U. S. Office of Education, OE-80041, mentioned previously. It contains detailed lists of equipment for the laboratories used in civil engineering technology programs along with estimated costs. A brief summary of some of the major laboratory equipment costs is indicated in Table VI.

**Table VI**

**Equipment Costs for Basic Laboratories in Civil Engineering Technology**

| Subject | Number of students per section | Equipment costs |
|---|---|---|
| Strength of materials | 16-20 | $32,000 to $40,000 |
| Highway materials (soils, concrete, bituminous material) | 16-20 | 15,000 to 27,000 |
| Surveying | 16-20 | 15,000 to 20,000 |
| Drawing and design (includes drawing tables, stools, and parallel rules) | 20-24 | 10,000 to 15,000 |
| Photogrammetrics laboratory (highly variable depending on equipment selected) | 16-20 | 8,000 to 10,000 |

There will be other laboratories depending upon the type of program that will be offered in hydraulics, water and waste water, air pollution, etc. The appropriate laboratories will have to be included in the early planning of the facilities.

The most important considerations will be to order the equipment for the first-year laboratories immediately and phase in the second-year laboratories after the program has started.

The importance of hiring qualified staff members cannot be overemphasized. The entire success of the program is dependent upon the quality of staff in the institution. The specialized nature of the curriculum requires that the teachers have special competencies based on technical proficiency in the subject matter and industrial experience. Another important consideration is that all members of the engineering technology faculty understand the educational philosophy of the institution and be in harmony with the goals and the unique organizational requirements that characterize this area of education.

To achieve the objectives of the curriculum, the subject matter cannot be taught as a series of independent courses, but must be presented in a closely integrated sequence of educational experiences. The staff must work together as a unit.

It is obvious that a substantial portion of the faculty teaching the technical specialty courses should be graduate engineers. Experience has shown that engineering technology graduates who have acquired industrial experience and have continued their education often make excellent teachers in this type of program. If the curriculum is to keep pace with technology, it is not feasible to depend to any great extent upon faculty members whose technical competence is only slightly greater than that of the students. The use of an unduly large number of part-time faculty members is undesirable.

Faculty members must maintain technical competence and should be encouraged to participate in the activities of professional and technical societies. They should also be encouraged to keep up with the literature in their field, continue their education, and maintain close liaison with industry in the area of their specialties. This encouragement is most effectively provided in the form of release time and financial assistance wherever possible.

Teaching loads should be based on contact hours rather than credit hours since, in general, this type of program requires the faculty member to spend a greater number of hours with the student than do other types of educational programs. Promotions should be based on the instructor's ability to bring a broad experience in academic background to bear on his students rather than solely on the acquisition of higher academic degrees. Good teaching should be the prime consideration in recruiting new faculty.

The salary structure and schedule must be organized in such a manner as to provide the necessary salary increments for the particularly unique experience of a faculty member in engineering technology programs. Recognition for being a registered professional engineer or a licensed land surveyor must have some equivalency in terms of years of industrial experience and/or additional academic training beyond the baccalaureate or master's level. The recent trend for developing leadership in engineering technology programs is to encourage a faculty member who has a master's degree in a subject matter field to continue on to obtain an Ed.D or Ph.D. in education where he majors in technical education. In many cases he would be able to take about one-fourth of his work in additional subject matter specialization, one-fourth in educational psychology, one-fourth in history and philosophy, and the remaining fourth of his work in problems relating to technical education, both pedagogy and research.

With each new curriculum, many situations and problems arise which are common to most other programs and can be discussed on a common ground. However, each new curriculum will have its own unique problems that must be assessed and solved individually. A great deal of individual initiative must be shown on the part of the faculty and administration in order to produce a good, sound civil engineering technology curriculum even under the best of conditions.

**Summary**

The purpose of this report is to bring to the attention of such interested parties as administrators of junior colleges, technical institutes, and governmental or industrial training programs some of the critical problems involved in training civil engineering technicians. The philosophy of technical education requires a considerable amount of attention, as well as the identification of the student population that can benefit from and most successfully complete a program of civil engineering technology.

The need for industry and governmental agencies to recognize how best they can employ graduates of two-year associate degree programs is a problem that needs focus by the professional organizations charged with the responsibility of maintaining high levels of performance of the engineering manpower team.

One of the most important conclusions that can be drawn from the conference and the report is that before a junior college is organized to offer a program in civil engineering or any other engineering-related technology, a qualified consultant can be of great value in helping to solve the problems connected with successful program implementation in any particular community. The points brought up in this report are significant not only for potential consultants, but also for the users of consultants.

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